DRAFT

xxxx-xx-xxxxxx
November 28,2007

Controlling Exposure in the Beryllium Work Environment

Beryllium Health & Safety Committee
Chronic Beryllium Disease Prevention Sub-committee

Members of the Chronic Beryllium Disease Prevention Sub-committee of the DOE Beryllium Health & Safety Committee and other contributors to this paper:

George Fulton, CIH, LLNL, Chair
Terence Civic, BWI
David Deubner, MD, MPH, BWI
Kimberly Ellis, CIH, LANL
Tiffany Defoe, OSHA
William G. Frede, CIH, Kansas City
Debra Hurst, RN, BWXT, Y-12
James Jenkins, CIH, BWXT, Y-12
Terence Jenkins, LANL/AWE
Larry Jones, DOE/NNSA, Y-12 Site Office
Marc Kolanz, CIH, BWI
Clive Le Gresley, AWE
Anthony Quinn, AWE
Sally Tinkle, Ph. D., NIOSH (presently with NIH)
Jon (Kevin) Baldwin, K Tech Corp.
Lynne Woodside, NGK Metals Corp.
Steven D. Jahn, CIH, WSRC

Formatted: Left: 1.25", Right: 1.25", Suppress Endnotes, Footer distance from edge: 0.6"

Controlling Exposure in the Beryllium Work Environment

This paper provides general recommendations and guidance for controlling exposure by all routes in beryllium work areas, that is, areas where exposure to airborne beryllium and surface contamination is possible. In the context of this position paper, exposure is defined as when a hazardous agent (beryllium) contacts a human organ surface (skin, lungs) such that harm will occur.

Successful achievement of exposure control requires commitment at all levels of an organization: workers and management.

1.0 Introduction to the Issue

Beryllium is a strategic metal with unique physico-chemical properties that make it indispensable in the aerospace, ceramics, nuclear, and telecommunications industries, as well as for other products in common use. Beryllium can cause sensitization (BeS) in a small percentage of the exposed population, and in a smaller percentage, chronic beryllium disease (CBD), an incurable lung disease.

Not all workers exposed to beryllium become sensitized or develop disease. For those that develop CBD, the rate of progression and severity of disease differs with each individual.

Beryllium sensitization is an immune system response to beryllium exposure. Sensitization has no symptoms, and presents no impairment to the individual. Sensitization can be determined by the lymphocyte proliferation test (BeLPT). This is a test in which the lymphocytes are challenged with various concentrations of a soluble beryllium compound, and their response is measured. If the lymphocytes multiply, or proliferate above a threshold, then the individual is considered "sensitized." Confirmation is by a second BeLPT. Sensitized individuals may eventually develop CBD.

Before the late 1980s, workers were diagnosed with CBD only when they exhibited clinical (observable) symptoms of CBD and changes in their chest x-ray or pulmonary function test. During the late 1980s and early 1990s, the criteria by which CBD was diagnosed changed to include workers without clinical symptoms or measurable impairment. These workers are often described as having sub-clinical CBD, which is diagnosed based on the presence, upon biopsy, of microscopic biological lung formations called granulomas.

Clinical CBD may vary from mild symptoms to significant impairment. Workers with sub-clinical CBD may never develop clinical CBD or may develop clinical CBD over time. There is no cure for CBD, but it is treated symptomatically.

How an individual becomes sensitized or develops CBD continues to be an area of active research, but remains unknown. There are a number of hypothesis, as of yet unproven, for example:

- Both sensitization and CBD are due to pulmonary exposure alone.
- Skin penetration plays a role in sensitization; subsequent pulmonary exposure results in disease.
- Sensitization begins with an initial exposure; CBD develops after subsequent exposure.

There is agreement that a lung dose is necessary to elicit an inflammatory response in the lung. Beryllium appears to remain in the lung. This in turn suggests that protection of the lungs needs to be a primary focus of a program to control exposure.

The significance of exposure of intact skin in sensitization or disease is unclear (see *NIOSH Beryllium Research Highlights*, July 2005). Cuts and abrasions on the skin are routes of entry for contamination. Beryllium-containing fragments embedded in the skin are known to cause granulomas that do not heal until excised.

Ingestion is also a route of exposure; toxicity by this route has not been considered to be significant. However, noting the uncertainty in development of sensitization and disease, exposure by this route should not be discounted.

Regardless, it is appropriate industrial hygiene practice to minimize beryllium exposure. This is a prudent course of action based simply on general industrial hygiene principles.

2.0 Exposure Pathways

Figure 1 illustrates several exposure pathways for beryllium exposure. The beryllium source can produce both airborne concentrations of beryllium as well as surface contamination with beryllium on working and walking surfaces. All of these sources may contribute to worker exposure.

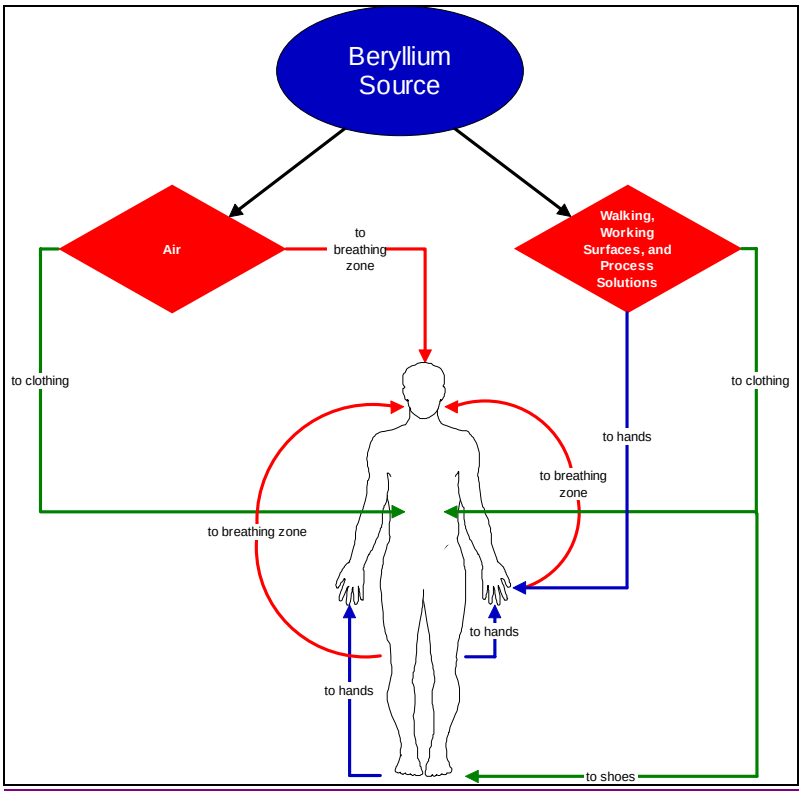

Figure 1.

Pathways may be segregated into Primary (Fig. 1: red lines): source to breathing zone; and Secondary (Fig. 1: blue lines), or Tertiary (Fig. 1: yellow lines): source to various surfaces and subsequent re-suspension. "BZ," or breathing zone refers to its usual definition as well as transfer of contamination to the face by the hands.

The primary goal of a control program is to prevent exposures by interrupting these pathways that may result in lung exposure.

The Primary Path (source to air to inhalation; contaminated clothing to inhalation): this pathway is subject to traditional industrial hygiene intervention. That is, enclose the process, use exhaust ventilation, or if these are not sufficient or feasible, then use respiratory protection.

To a certain extent, enclosure or exhaust ventilation can affect the other potential indirect pathways whereby contamination is deposited on surfaces and through various mechanisms, is re-suspended and results in a potential inhalation risk.

The Secondary Path (contamination to hands to inhalation): handling contaminated items (parts, clothing or protective equipment). Contamination is transferred from parts to hands and is then suspended in the air.

The Tertiary Path (source to air/walking, working surfaces to hands to inhalation): contamination from these sources may be re-suspended, and result in an inhalation exposure.

Therefore, beryllium work areas should be kept as clean. Prevent re-suspension of contamination from the work piece or surfaces. Beryllium-containing dust be kept off the person.

Due to the nature of beryllium, a management approach for the full lifecycle of its use within a Hazardous Materials Management philosophy is encouraged. Rigorous process mapping for each material should occur. This includes manufacturing process flowpaths; contamination of engineering controls media pathways like through down draft systems, ventilation bag houses , and servicing of controls components such as gloveboxes, hoods, etc. In addition, every support activity (product specification sampling, radiological decontamination, ventilation efficiency tests, washdown collection tank draining, etc.) should be explored not only to its proper and logical conclusion, but also under its failure modes: leaking isolation valves and subsequent evaporation of spill surfaces.

Only then can true hazardous materials management be employed in control of personnel exposures to beryllium.

4.0 Sources of Exposure

Opportunity for exposure to particulates in the workplace abound. Particulates are formed as part of metal forming and finishing operations, metal handling, as well as facility and equipment maintenance:

- airborne exposure from powder handling operations,
- airborne exposure from material finishing activities (cutting, grinding, machining, milling, polishing, etc) involving the metal, alloys, and compounds,
- airborne exposure from poorly or inadequately exhausted machining enclosures,
- maintenance on exhaust ventilation systems, including HEPA vacuum cleaners
- maintenance on beryllium process equipment or facilities,

- handling of contaminated material, including protective clothing, as well as improper donning and doffing of clothing or equipment.

5.0 Standards

Standards have been established for airborne exposure and surface contamination, both for beryllium work areas and release from control, have been established:

Airborne, permissible exposure limit	2.0 µg/m^3, 8-hour time weighted average
Airborne, action level	0.2 µg/m^3, 8-hour time weighted average
Surface, housekeeping	3 µg / 100 cm^2
Surface, release	0.2 µg / 100 cm^2

The permissible exposure limit, or PEL, was set by OSHA as the federal occupational exposure standard. The action level and the surface criteria were set by the DOE for use at its contractor sites. The ACGIH threshold limit value®, or TLV, is presently the same as the OSHA PEL.

Other surface criteria have been established in plants where the DOE criteria are not applicable.

The OSHA PEL and ACGIH TLVs are presently under review. Exposures should be kept as low as practical. The technical basis for the surface contamination criteria has not been established.

4.0 Recommendations

The specific controls for a particular activity should be commensurate with the risk and should be determined based on a hazard/risk assessment. The following practices for beryllium work areas may be used:

Engineering Controls

- Use recognized methods of engineering control to either enclose or exhaust processes that may generate a beryllium aerosol.
- Housekeeping should be conducted using work practices, e.g., no dry sweeping, and engineering controls, e. g., dedicated HEPA vacuums, to prevent re-suspension of contamination.
- Control of work practices needs to consider, and minimize, activities that may abrade or cut the skin.

Administrative Controls

- Beryllium work areas should be demarcated from non-beryllium work areas by signs, markings, or barriers appropriate to the work place.
- Train workers in contamination control to minimize, to the extent feasible, those practices or actions that may re-suspend beryllium aerosols, including proper handling (donning/doffing of protective clothing that may become contaminated).
- Conduct initial and routine air sampling to validate the adequacy of controls to minimize airborne exposures.
- Institute a monitoring program to track levels of contamination in the workplace; pay particular attention to rising trends in contamination level regardless of status versus administrative control levels. A useful tool may be control charts for this purpose.
- Use of personal items that may become contaminated and are not readily cleaned should not be permitted in areas with the potential for particulate contamination.
- Eating, drinking, smoking, applying cosmetics shall not be permitted in beryllium work areas.
- An assessment program shall be established to ensure that all appropriate elements of a control program are measured and evaluated.
- Consideration in all of the previous matters should incorporate Human Performance initiatives so that the worker has full control and authority for the management of exposures and contamination levels. This extends to accountability being assigned to these same elements of the workforce.

Personal Protective Equipment

- Procedures should be established to prevent contact of skin with any contaminated surfaces.
- Cuts (wounds) or abrasions on the hands or other locations shall be covered to prevent contamination from beryllium.
- Supplement engineering controls with protective clothing (coveralls or full body clothing, gloves, safety shoes or shoe covers, respirators) appropriate to the task.
- Change rooms should be provided for workers to remove personal clothing, and procedures put in place to protect it from contamination. Where conditions require, dedicated showers should be provided, with workers required to shower after removing protective clothing and before changing into personal clothing.

5.0 References

10 CFR 850, Chronic Beryllium Disease Prevention Program

DOE G 440.1-7A, Implementation Guide for 10 CFR 850, Chronic Beryllium Disease Prevention Program, January 4, 2001

29 CFR 1910.1000, Air Contaminants

ACGIH, Documentation for the TLV – Beryllium

ACGIH, Industrial Ventilation Manual

AIHA, Sampling Strategy Manual

AWE, "Standards and Guidance, Management of Exposure to Beryllium at AWE", OH/A/400-T/OH/02.54/C02.73

NIOSH Beryllium Research Highlights, Number 2, July 2005.

OSHA, Trade News Release, "OSHA Alerts Workers to Beryllium Exposure," September 17, 1999